Carbohydrates and glycogene loading

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Carbohydrates in Performance Horses

The substrates for athletic performance in the horse, the human, the rat, and the elephant are all the same: carbohydrate-derived, protein-derived or various forms of fat. That is to say, the horse is not from Mars. The horse is a mammal, with mammalian energetics. In this regard, there is no need to reinvent the known science to fit the horse.

The literature suggests that carbohydrate-derived muscle fuels are the dominant factor in both power production and fatigue resistance, and this has proven true in practical application, from high speed racehorses to 100-mile endurance horses--just as the literature from human exercise science has predicted.

Here is an economic paradigm that is reflected, in substance if not scale, throughout the world of performance horses: The Thoroughbred that consistently delivers a racing mile in one minute and thirty-seven seconds is a $30,000 horse. The Thoroughbred that consistently delivers a 1:33 mile is worth many millions of dollars. In short, improved performance is a tremendous economic lever in our world, as it is in every athletic endeavor. Those of us involved in providing support services to the performance horse world must focus primarily on performance, consistency, and longevity. Proper use of carbohydrate in the diet can be an extremely productive tool.

Carbohydrate and Fatigue Resistance

In human athletes, muscular fatigue reduces performance in athletes competing in events lasting from 10 seconds to several hours. The whole thrust of training and nutritional protocols focuses on reducing or delaying the onset of fatigue. In performance horses the problem is more severe because not only does fatigue lose races, but it leads to injury. The biomechanics of the horse are such that muscle fatigue results in changes in gait and lower leg posture which in turn predispose the animal to a variety of career-ending injuries, from bowed tendons and torn suspensories to chips and fractures and joint deterioration.

For decades it has been thought that the primary culprit in the cause of fatigue in race horses is lactic acid buildup. It was also thought that lactic acid production was due to a lack of oxidation potential at the muscle cell level. Academic research tended to support these conclusions because elite athletes were shown to have higher lactic acid thresholds (VLA4) than those with less training or inferior oxidative delivery/uptake. For decades, then, training protocols and nutritional supplementation--and even illegal drugging--focused on the oxidative side of the equation--
bigger, more efficient hearts, expanded plasma volume, expanded capillarization, increased red cell production, increased mitochondrial density. All of these factors could be manipulated through sophisticated conditioning routines and supportive nutrition.

Digging deeper into the substrate aspect of fatigue resistance, we've recently seen a number of papers that come to similar conclusions as the following paper.

T Reilly, V Woodbridge
Effects of moderate dietary manipulations on swim performance and on blood lactate-swimming velocity curves
International Journal of Sports Medicine, 1999, Vol 20, Iss 2, pp 93-97Georg Thieme Verlag, P O Box 30 11 20, D-70451 Stuttgart, Germany

The results indicate that a moderate reduction in CHO intake alters swimming performance adversely whereas a moderate elevation in CHO intake above the normal diet improves performance. The dietary manipulations affected the response of blood lactate to both submaximal and maximal swimming velocities. The observations highlight the limitations of applying lactate response curves to swim training.

The investigators are concerned that a high carbohydrate diet interferes with their testing for performance capabilities. The athletes fail the VLA4 test but perform better—a “paradox” to these researchers. This parallels our experience on the racetrack with "glycogen loaded" horses.

Seven years ago, I was called in as a consultant to determine the cause of bad racing performance in a horse named Acey Mack, racing in Portland Oregon. For several races in a row, at 6 furlongs, this horse would come around the turn in front only to stop so badly that the horses behind him had to get out of his way as he backed through them. He'd finish last or next to last. An extremely complete diagnostic workup was performed, including post-race blood analysis, to no avail. Nothing was wrong with this horse--he wasn't bleeding, had no airway obstructions, no fractures, no abnormal blood parameters, no heart problems. His immediate post race blood lactate was 22 mmol and his post race CK was 350.

We ran the horse back one week later, but during that week, we "glycogen loaded" him—a process that consisted of his normal ration supplemented with a 4 ounce dose, 3 times a day, of a maltodextrin/chromium polynicotinate powder over a period of four days, including the next race day. In this race, he was second by a nose--an estimated performance improvement of 15 lengths according to Daily Racing Form charts. The next week he was second by a nose again. Then he won four races in a row, racing weekly for the most part. Blood was sampled immediately post race after the first glycogen loaded race. CK was 250, lactic acid was "out the roof"--greater than 35 mmol.

Thus, the "paradox" of no fatigue with very high lactate numbers in the face of greatly improved performance. We are led to the conclusion that 1) lactic acid buildup has minimal impact on fatigue, 2) higher levels of stored muscle glycogen will result in more glycogen being used in a
race and result in higher lactate production, 3) in spite of higher lactate levels, the extra available substrate results in greatly improved racing performance.

Of course, Acey Mack represents "one-rat research". In the seven intervening years, several thousand more "rats" have demonstrated decided benefits from this "glycogen loading" protocol.

A Central Problem

In the early days of our "applied research" on the racetrack using glycogen loaders we ran into a serious problem. For some reason, unknown to us at the time, about 10% of the horses we glycogen loaded delivered the very worst performance of their lives. They ran "flat". Our first guess as to the etiology of this disastrous result was that something else that was being given to the horses was reacting poorly with the glycogen loader. There was no health threat--the horses would come out of their poor races happy and healthy--and apparently "ready to race again, right now".

The story of how we eventually solved this problem is long and tedious and full of trial and error- I'll cut to the chase: If, at post time, the horse's blood glucose is either crashing or at a low point, he will race "flat"--just not be capable of making competitive racing speeds. The solution is to ensure that the animal's blood glucose is elevated, and not crashing, at post time. Two pounds of grain, fed two hours out from post time, completely eliminates this problem.

Why does this phenomenon occur? We know that it happens with non-glycogen loaded horses as well. If a trainer's routine is that every horse gets fed at 11 AM on raceday, and some horses race at 1:00 in the afternoon and others race at 5 PM, about 10% of those racing later will suffer from the same "flatness" as do the glycogen loaded horses. The trainer will say, "He wasn't himself today", or "He just didn't fire". In some stables, this has led to running glucose response curves on every horse in the stable in order to determine precisely what the blood glucose will be at post time in the individual horse.

It is my unproven theory that at the time the rider pushes the "go" button, coming out of the starting gate, and demanding a sudden 110% effort, the central nervous system takes a quick survey of available survival fuel--blood glucose. If there is a CNS-perceived blood glucose crisis, then the CNS inhibits muscle firings. We know that the CNS is capable of this kind of inhibition- -Guezennec (2000) elucidates at least one mechanism. The factors that trigger this action are yet to be catalogued in the literature.

Loading Versus Supplementation

Some equine events require lower levels of muscular activity and increased precision in skilled performance (dressage). Others combine skills with tests of fitness (eventing). Still others demand relatively low level muscular performance for extended periods of time (endurance). We
have found that a loading protocol used prior to skills competition typically does more harm than good. The horse has too much energy and makes enthusiastic errors. But in a 3 day event, beginning an abbreviated loading protocol immediately after the dressage section should produce a beneficial result as long a proper timing considerations are observed.

A similar problem is encountered when attempting to glycogen load for endurance horse competition. In this case, if you begin a 100 mile race with a very enthusiastic, bursting with energy horse, The horse either goes too fast or spends a lot of effort fighting with the rider--you soon run into elevated body temperatures and dehydration--this is the worst possible scenario for the beginning of a 7½ to 14 hour competition.

We are now supplementing fact-acting carbohydrates all along the way--4 ounces of the same glycogen loader formula mentioned above every 1½ hours, beginning with one dose 15 minutes before the start of each loop. (An endurance race might consist of approximately 5 loops of, to round out the numbers, 20 miles each, with rest periods and veterinary checks between those loops). Water and electrolytes are also given periodically throughout the ride. In these contests, a large percentage of the competitors is unable to finish--many simply "run out of gas" and cannot press on; others run headlong into severe metabolic distress and must be treated quickly with IV fluids. Many of these latter are demonstrating very low blood glucose at the time they are pulled from competition.

Those horses that are properly supplemented with carbohydrates (and electrolytes and water, of course) tend to be enthusiastic performers to the end of the contest and pass veterinary checks with ease--barring physical injury. Those that are improperly supplemented with the loader formula crash, often sooner than the others that were not supplemented. Improper supplementation occurs when the supplement is not fed frequently enough or when it is stopped halfway through the race for one reason or another. Thus, if you are going to supplement fast-acting carbohydrate during an endurance contest, you have to do it frequently and you cannot stop until the contest has finished.

So, 4 ounces (128 gm) of maltodextrin/chromium fed every 1.5 hours (perhaps as much as 40 ounces in a 100 mile event) is ergogenic in 750 to 1000 lb horses exercising for hour after hour at heart rates typically ranging between 115 and 145. Dehydration and hyperthermia are not problems that these supplemented horses face--again, given proper electrolyte and water maintenance (hyperhydration in the days leading up to the event also appears productive).

Those are the well-documented results from the "coaches and athletes" in the field. But can we explain why, scientifically? Does the literature offer a hint as to why a primarily aerobic and fat-based substrate metabolism would be enhanced by frequent carbohydrate supplementation?

The first thing we see in the literature are numerous studies supporting both glycogen loading prior to endurance competition and frequent "sports drink" (water, glucose and electrolytes) intake during competition in human athletes. These protocols are clearly ergogenic.
Let's look at the available substrates. Muscle glycogen, liver glycogen, stored intramuscular di- and triglycerides, blood glucose, protein, and adipose tissue in addition to gut contents of fiber. In comparison to the energy available from these sources, even 40 ounces of "loader" or lesser amounts of "sports drink" glucose in human athletes, seems insignificant as a working substrate. Something else is happening.

One thing we know is happening because of field studies is that the rate and quantity of loader dosage will maintain an elevated blood glucose throughout these endurance races. In fact, some tests have shown a continuous rise in blood glucose as the event grinds on. From the science we know that elevated glucose means elevated insulin and that in turn results in a decided inhibition of lipolysis. So, with carbohydrate supplementation, adipose tissue becomes a less important player in the working substrate mix.

However, the stored muscle fats, the di- and triglycerides, are always readily available and probably contribute greatly to the exercise energy pool at these low intensities. And recent science is hinting that these "fats" are somewhat hybrid in form--not quite true fats, not quite sugars. But fast-acting, nevertheless. And I'm old enough to remember the old adage "fat burns on the flame of glycogen". Meaning that once muscle glycogen is depleted, the performance is over, no matter how much fat is still available. And, once blood glucose is gone, the Central Nervous System dies. Before that happens, though, the CNS will shut down the activities of all the other organs to preserve fuel for itself--starting with the working muscles. So the glucose-depleted athlete comes to a near standstill.

We know, too, that part of the ergogenic effect of carbohydrate supplementation in human athletes is the beneficial effect on "perceived exertion". That is, the athlete feels better with an elevated blood glucose. In fact, there is evidence from the higher intensity middle distance events, 5K and 10K runners, that "hitting the wall" of fatigue occurs as carbohydrate-based substrates are depleted to the extent that the body makes a concerted attempt to switch substrate metabolism toward fats in an attempt to allow glycogen/glucose sparing and give the liver time to regenerate glucose through gluconeogenesis and protein catabolism (blood ammonia levels track well with this type of fatigue).

Given adequate water and electrolyte intake, if we can maintain elevated blood glucose during an extended endurance race, we can prevent a "crash" in performance by maintaining a carbohydrate-driven metabolism.

**Safety in Feeding Carbohydrates**

To date we have experienced no adverse reactions to sometimes very large carbohydrate supplementations. No tying up, no colic, no laminitis, no induced diabetes. We use a longer chain maltodextrin in order to smooth out the glucose response curves from doses of glycogen loaders. We add chromium so as to help avoid overloading the insulin system.
We advise our clients to feed normal balanced rations, spread out over several feedings a day and consisting of a 50-50 concentrate/forage intake--primarily grass hays for the forage. The highest grain intake I've observed was 26 pounds of mixed grains a day, spread over five feedings, in a mare named Stanerra, who won the Japan Cup, among other Grade I stakes. She consumed a like amount of hay. Her workload was strenuous--up to 15 miles a day.

Our generalized rule as far as daily carbohydrate feeding is concerned is to "feed the work". But the daily intake remains constant, with no half-feed days and full-feed days. We avoid days off, where the horse performs no exercise, particularly with racing-fit horses. We try to ensure that the horse either gains or maintains body weight throughout the conditioning and competition processes. In some stables, the horses are weighed every day. The recovery/supercompensation cycle tracks with body weight fluctuations.

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